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APPLICATION NUMBER: ***60/547,168***
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RELATED PCT APPLICATION NUMBER: ***PCT/US05/05597***

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14023 U.S. PTO
022504

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. ET 889956556 US

INVENTOR(S)

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☐ Additional inventors are being named on the ____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (280 characters max)

Wafer Scale Fabrication of Nanoscale Scanning Probes for Biological and High Frequency Applications

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ENCLOSED APPLICATION PARTS (check all that apply)

☒ Specification Number of Pages 4

☐ Drawing(s) Number of Sheets ____

☐ Application Data Sheet. See 37 CFR 1.76

☐ CD(s), Number

☒ Other (specify) Postcard

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☒ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees.

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 50-1742

☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($): 80

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☐ No

☒ Yes, the name of the U.S. Government agency and the contract number are: **Grant No. awarded by the DARPA**

Respectfully submitted,

SIGNATURE [signature]

Date 2/24/2004

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Wafer scale fabrication of nanoscale scanning probes for biological and high frequency applications

Abstract:

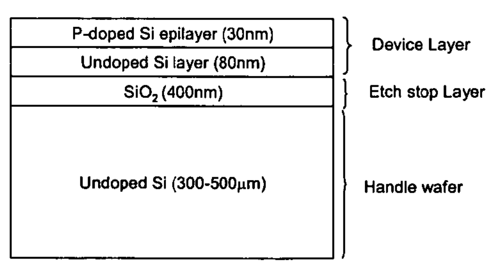
The present art describes the design, fabrication and characterization of nanoscale cantilevers that can be used for scanning probe microscopy of biological samples. The dimensions of the cantilevers fall into nanoscale regime. For example, the thickness of the cantilever can be as thin as 30nm. The width of the cantilevers is as narrow as 400nm. These dimensions match the size of cells and offer high resolution in scanning probe microscopes (SPM). Meanwhile, the small dimensions of the cantilevers allow them to be operated at much higher frequencies and yield faster temporal response (as fast as 1uS).

The fabrication process employs a wafer scale nanofabrication technique that is capable of producing hundreds of cantilevers from one wafer. The silicon chips that house the cantilever match the size of the chips used in the SPM market. They also have electronic circuits that can interface directly into commercial scanning probe microscopes and provide force-sensitive electrical signal.

Two types of force transduction schemes are proposed and tested on these nanoscale cantilevers: piezoresistive detection and optical detection. The former relies on the high piezoresistivity of epitaxially grown p+ silicon layer embedded in the cantilever. Optical detection is realized by extending the nanocantilever with a larger micron-scale reflecting pads. Both methods have demonstrated high sensitivity in the fabricated devices

Material for piezoresitive detection:

The structure is 30 nm p-doped (4 E 19 Be/cm^2) Si epilayer grown on 80nm undoped Si layer, on top of 400nm of SiO_2, on 300μm thick handle wafer oriented in [100] direction. This will maximize the piezoresistive constant along the [110] direction and ease fabrication and alignment of scanning probes.[1] See Figure 1.



Material for optical detection:

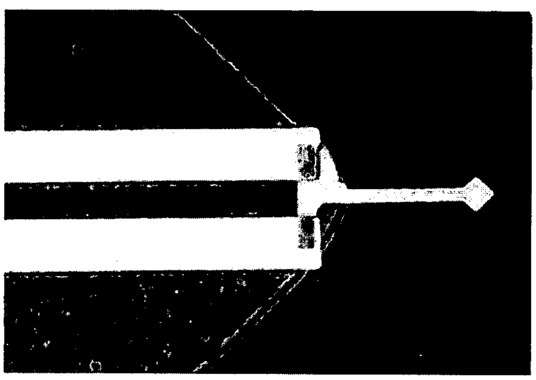
A similar structure is designed for optimal detection. Here the p-doped layer is eliminated.

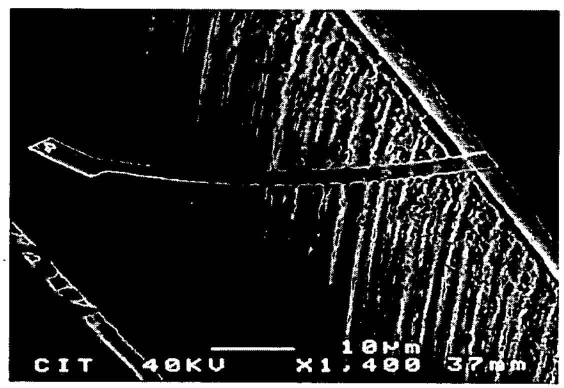
Probe design for piezoresistive detection:

Align probe pattern along direction with maximum piezoresistive coefficient. Design scanning probe with electrode "legs" to form a stress concentration region where the current passes the most compliant area of the probe, maximizing piezoresistive response with actuation.[1]

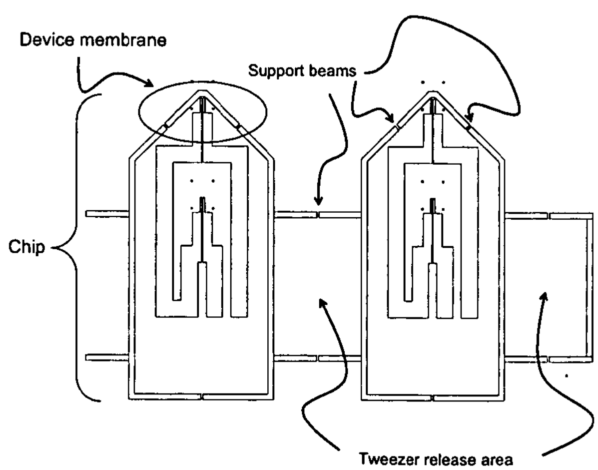
Probe design for optical detection:

Design scanning probe with at least ~1um^2 reflective area near the tip of probe. Evaporate/sputter metal (i.e. 20nm of Au) on area near probe tip. This allows diffraction limited optical feedback to be utilized in commercial scanning probe microscopes (see Figure 2).

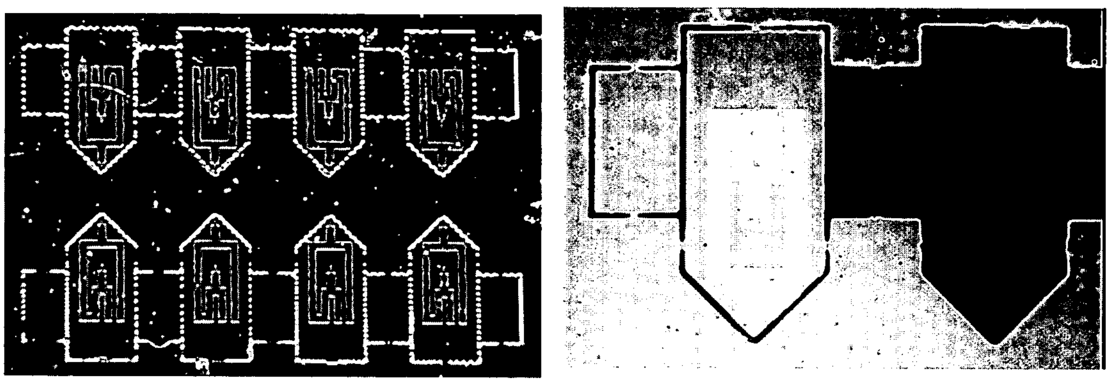




Release Structure Design:



Define temporary support structure for probe chip during nanoscale fabrication and two release areas enabling tweezer removal of chip. (See Figure 3). Two support beams are placed near the tip of chip to protect membrane from tearing prior to defining scanning probe tip. One support beam is use to support rear end of chip to wafer. Support beams have to be strong enough to withstand future wafer-scale processing of scanning probe while compliant enough to be broken for chip removal from wafer (i.e. 25 X 70 X .1 microns).

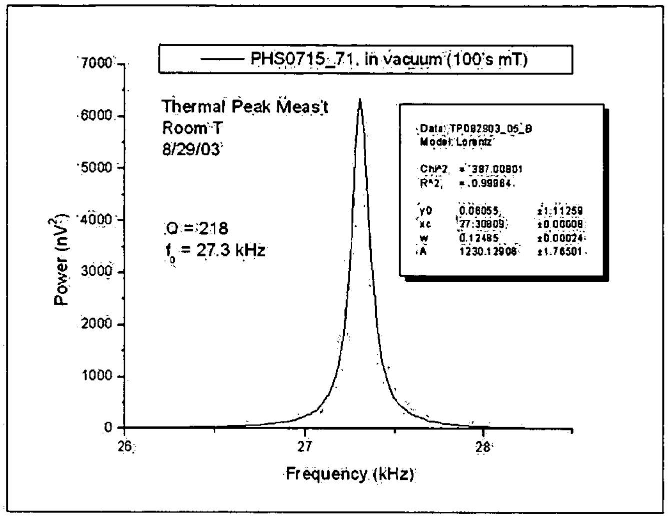


Process Flow:

1) Electrode fabrication: ohmic metal evaporation, define electrode pattern with photolithography, wet etch
2) Membrane and release-structure fabrication: Deep Reactive Ion Etching through Si handle wafer
3) Oxide removal: buffered oxide wet etch
4) Cantilever definition: electron beam/ photo lithography of mask
5) Cantilever fabrication: etch cantilever shape in piezoresistive membrane
6) Release of scanning probe chip: pull out chip from wafer with tweezers

Characterization:

Optically detected signal (Figure 4)



Piezoresistive detection signal (Figure 5)